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(54) Reducing delays in a multiplex communication system

(57) A multiplex communication system, for example in a vehicle, has a plurality of node devices 1 to 11 connected via a bus line 21 to at least one of a plurality of end node devices to be controlled 12 to 15. As the number of nodes increases, the delays involved in transmitting data along the bus can become unacceptably long. Therefore, the data is divided into a plurality of categories according to the necessity of transmission. For example, engine management data that needs to be transmitted more urgently than door mirror control data has a higher necessity of transmission. The more urgent data is transmitted once every multiplex transmission cycle, while the less urgent data is transmitted once every few transmission cycles, according to the necessity of transmission. This reduces the delays. Alternatively, the transmitting and receiving nodes can be identified without having to append address data to the message data. One of node devices serving as the master node device M sets the transmission cycle of message data transmitted onto the bus line 21 as a cycle of a start pulse that is sent to the bus line 21. This cycle has been set so as not to cause a time lag in data processing executed by the respective node devices. Each time interval between the start pulses is divided into a plurality of time slots. The time slots have been allocated to the individual node devices so that message data can be transmitted from the respective devices in the associated time slots without the need for address data, thereby reducing delays.

FIG. 1

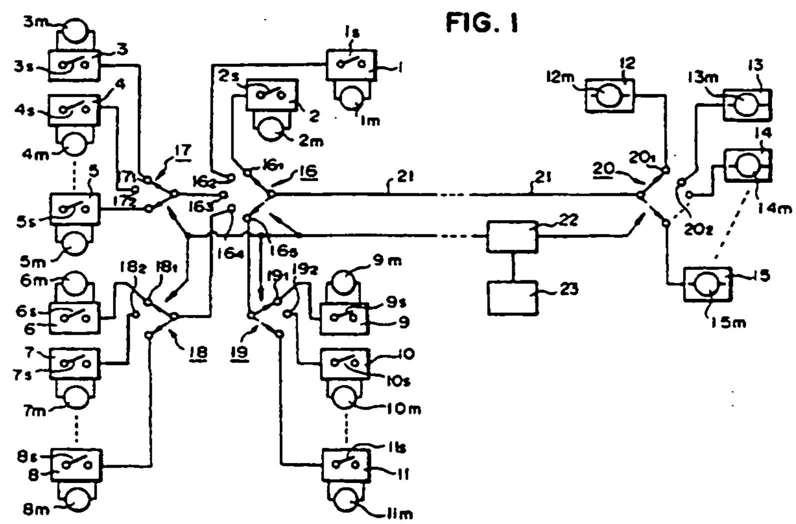

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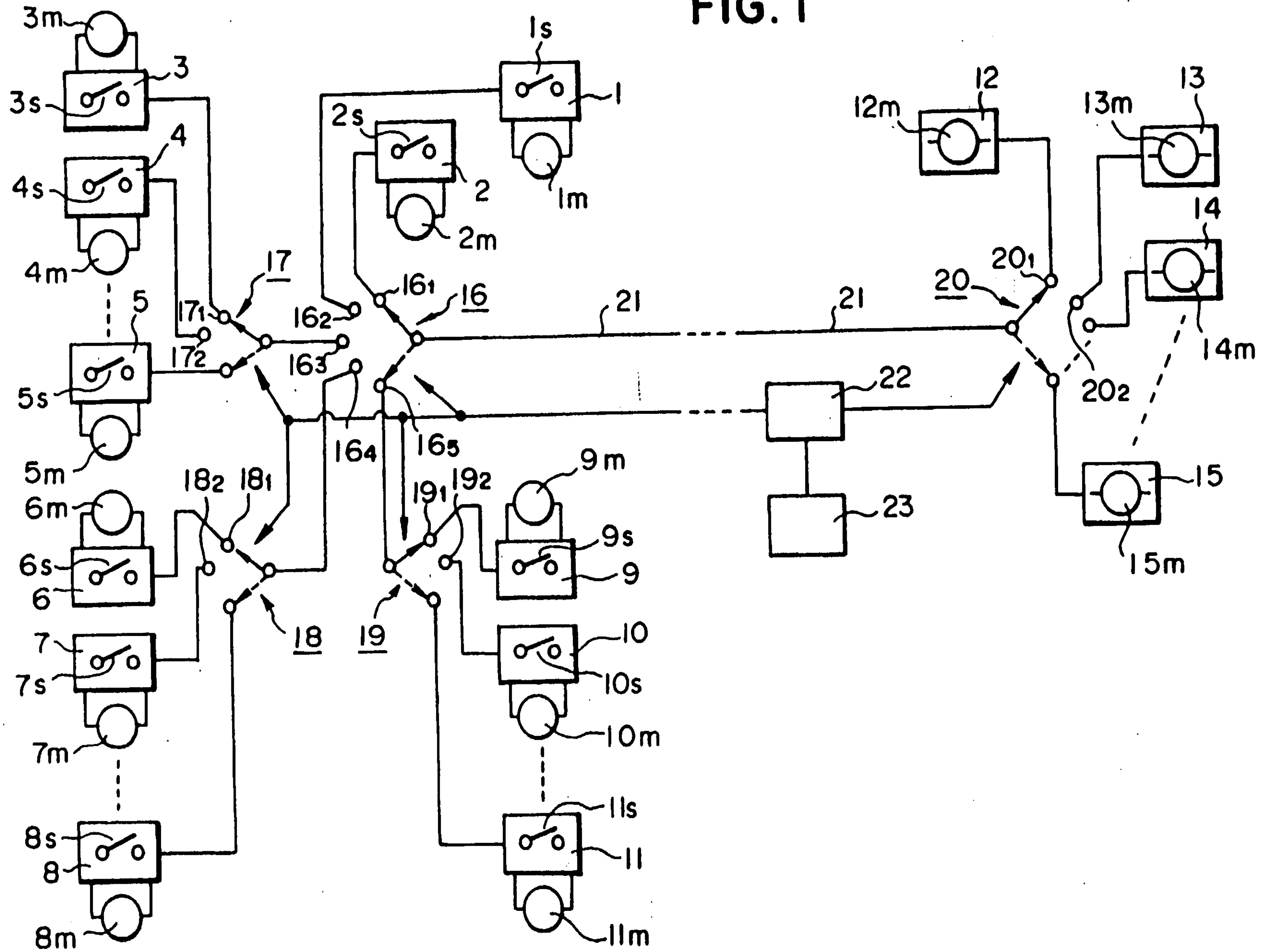
FIG. 1



1s
1
1m
2s
2
2m
3m
3
3s
4
4s
4m
5
5s
5m
6m
6s
6
7
7s
7m
8s
8
8m
9m
9s
9
10
10s
10m
11s
11
11m
12
12m
13
13m
14
14m
15
15m
16
16_1
16_2
16_3
16_4
16_5
17
17_1
17_2
18
18_1
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19
19_1
19_2
20
20_1
20_2
21
21
22
23

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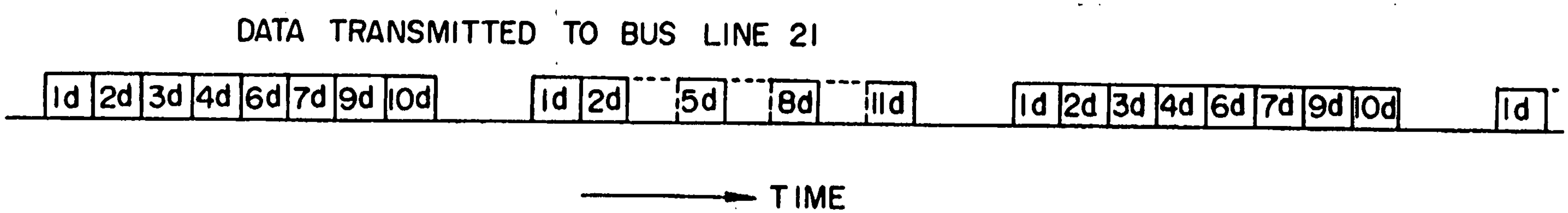
FIG. 2



DATA TRANSMITTED TO BUS LINE 21
1d 2d 3d 4d 6d 7d 9d 10d
1d 2d 5d 8d 11d
1d 2d 3d 4d 6d 7d 9d 10d
1d
TIME

FIG. 3

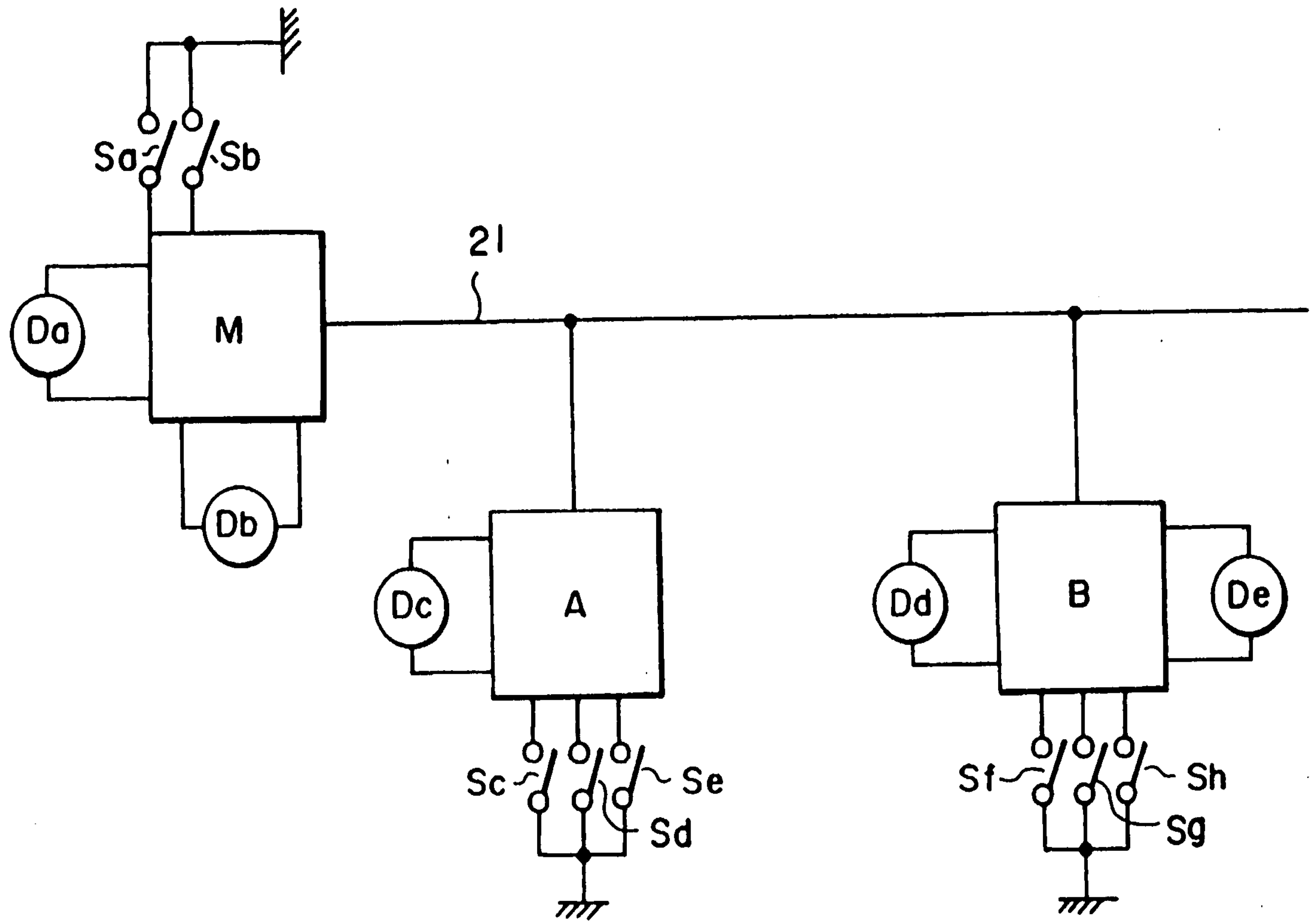
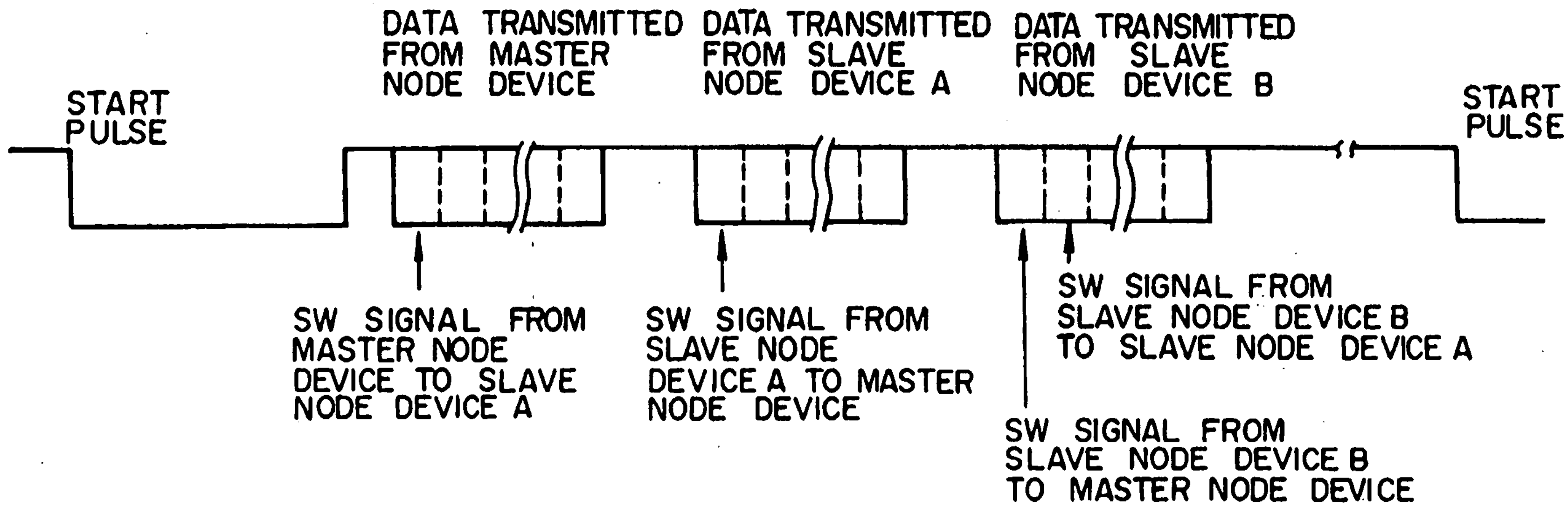
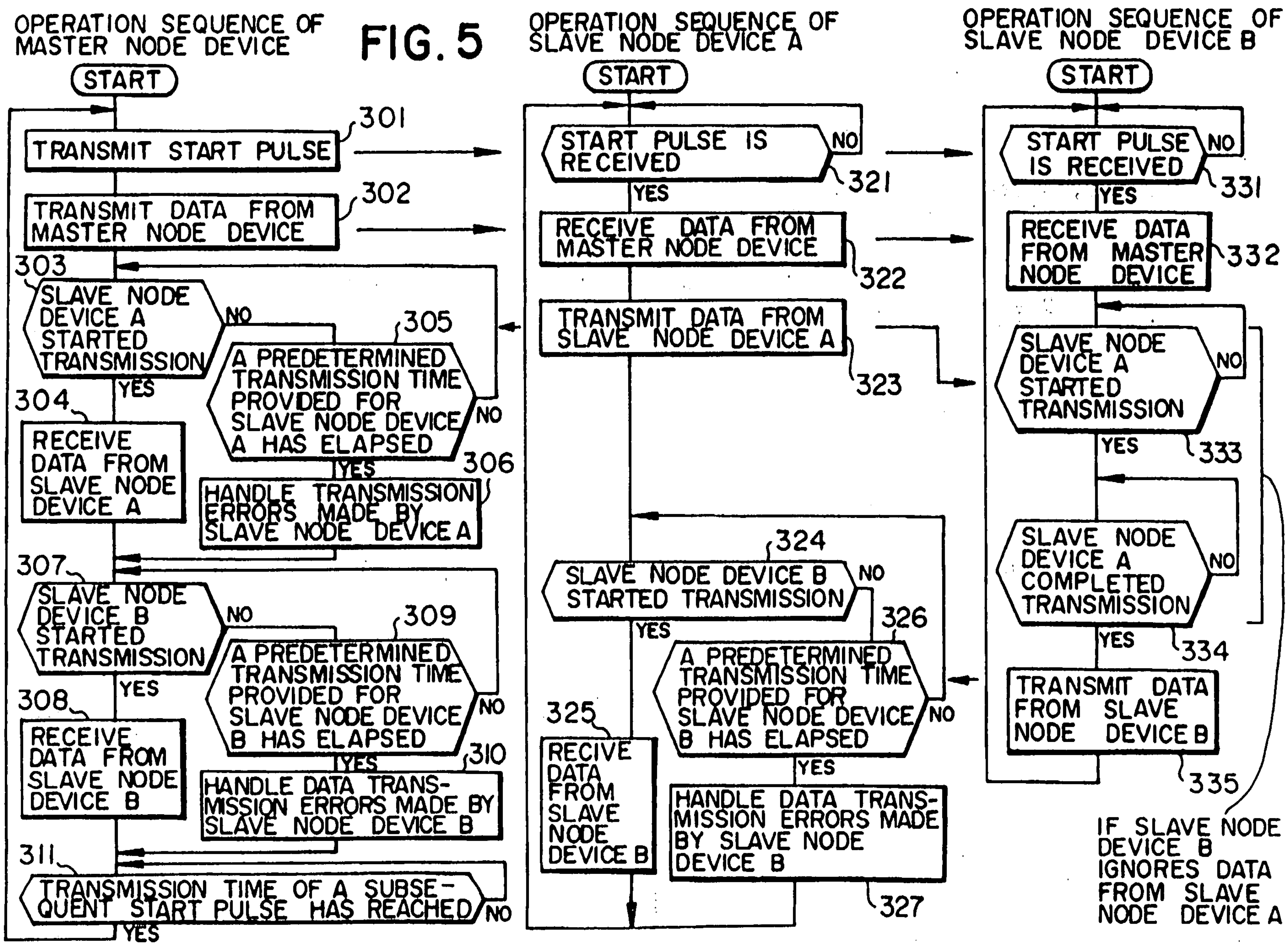


FIG. 4


START PULSE
DATA TRANSMITTED FROM MASTER NODE DEVICE
DATA TRANSMITTED FROM SLAVE NODE DEVICE A
DATA TRANSMITTED FROM SLAVE NODE DEVICE B
START PULSE
SW SIGNAL FROM MASTER NODE DEVICE TO SLAVE NODE DEVICE A
SW SIGNAL FROM SLAVE NODE DEVICE A TO MASTER NODE DEVICE
SW SIGNAL FROM SLAVE NODE DEVICE B TO SLAVE NODE DEVICE A
SW SIGNAL FROM SLAVE NODE DEVICE B TO MASTER NODE DEVICE

4/5

FIG. 5


OPERATION SEQUENCE OF MASTER NODE DEVICE
START
TRANSMIT START PULSE
301
TRANSMIT DATA FROM MASTER NODE DEVICE
302
303
SLAVE NODE DEVICE A STARTED TRANSMISSION
NO
YES
305
A PREDETERMINED TRANSMISSION TIME PROVIDED FOR SLAVE NODE DEVICE A HAS ELAPSED
NO
YES
304
RECEIVE DATA FROM SLAVE NODE DEVICE A
306
HANDLE TRANSMISSION ERRORS MADE BY SLAVE NODE DEVICE A
307
SLAVE NODE DEVICE B STARTED TRANSMISSION
NO
YES
309
A PREDETERMINED TRANSMISSION TIME PROVIDED FOR SLAVE NODE DEVICE B HAS ELAPSED
NO
YES
308
RECEIVE DATA FROM SLAVE NODE DEVICE B
310
HANDLE DATA TRANSMISSION ERRORS MADE BY SLAVE NODE DEVICE B
311
TRANSMISSION TIME OF A SUBSEQUENT START PULSE HAS REACHED
NO
YES
OPERATION SEQUENCE OF SLAVE NODE DEVICE A
START
START PULSE IS RECEIVED
NO
321
YES
RECEIVE DATA FROM MASTER NODE DEVICE
322
TRANSMIT DATA FROM SLAVE NODE DEVICE A
323
324
SLAVE NODE DEVICE B STARTED TRANSMISSION
NO
YES
326
A PREDETERMINED TRANSMISSION TIME PROVIDED FOR SLAVE NODE DEVICE B HAS ELAPSED
NO
YES
325
RECIVE DATA FROM SLAVE NODE DEVICE B
HANDLE DATA TRANSMISSION ERRORS MADE BY SLAVE NODE DEVICE B
327
OPERATION SEQUENCE OF SLAVE NODE DEVICE B
START
START PULSE IS RECEIVED
NO
331
YES
RECEIVE DATA FROM MASTER NODE DEVICE
332
SLAVE NODE DEVICE A STARTED TRANSMISSION
NO
YES
333
SLAVE NODE DEVICE A COMPLETED TRANSMISSION
NO
YES
334
TRANSMIT DATA FROM SLAVE NODE DEVICE B
335
IF SLAVE NODE DEVICE B IGNORES DATA FROM SLAVE NODE DEVICE A

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MULTIPLEX COMMUNICATION SYSTEM

The present invention relates to a multiplex communication system and, more particularly, to a multiplex communication system which is constructed to transmit operational data from a plurality of control units to at least one of a plurality of end devices to be controlled at different transmission frequencies in accordance with the degree of urgency.

The invention further relates to a multiplex communication system and, more particularly, to a multiplex communication system which is adequate to efficiently transmit and receive data formed of a plurality of bits among a plurality of transmitting and receiving devices, and which is thus suitable for collecting information indicating states of vehicle-loaded equipment and for controlling the driving of the equipment.

Generally, a typical communication system loaded in a vehicle is widely employed to transmit and receive data that is used for collecting information representing states of vehicle-loaded equipment, for controlling the driving of the equipment and for other purposes. The communication system of this type comprises a single bus line, a plurality of control units, i.e., node stations, connected to the bus line, and actuators attached to the respective node

stations. Message data transmitted and received among the respective node stations includes data for controlling the actuators and address data indicating the sender and the receiver of the message, and is transmitted cyclically onto the bus line.

Along with the substantial increase in the number of electrical equipment loaded in a vehicle, the amount of signal data passing through a bus line forming a communication system is also increasing. Message data in the system according to the technique discussed above is cyclically transmitted. For example, every time a transmission cycle is started, all the items of operational data, i.e., data 1, data 2, data 3, data 4 and data 5 which are output from first to fifth vehicle-loaded control units, respectively, are sequentially transmitted to the bus line.

The communication system of the above type presents the following problems. A larger number of control units for transmitting the operational data results in an increase in the number of items of operational data to be transmitted during one transmission cycle. Accordingly, the time interval between the transmission of the same item of data (for example, data 1) becomes longer, which delays the timing of transmitting the latest operational data (for example, data 1).

Additionally, each message data contains address data, which disadvantageously increases the amount of data transmitted to the bus line, thereby causing a greater time lag in the data processing of the entire communication

system.

Accordingly, various troubles may be caused due to such a delay in data processing in the above-described vehicle-loaded communication system. In particular, a delay in the data processing relative to the actuators, for example, a diagnostic system for the engine, such as a throttle sensor, which is required to be operated very quickly in response to data, is very critical. In other words, among the vehicle-loaded control units, some devices generate operational signals (data) which need to be transmitted urgently, such as a collision detecting section that generates air bag signals, a door lock/unlock detecting section that generates door lock/unlock signals, etc., while other units produce operational signals (data) which do not need to be transmitted urgently, such as a window opening/closing section that generates window opening/closing instruction signals, a mirror actuating section that produces remote control mirror driving signals. A time lag in the transmission timing of the former type of signals (data) that need to be transmitted urgently jeopardizes the safety for the driver and passengers. It is thus very important to solve this problem.

Accordingly, in order to solve the problems inherent in the technique discussed above, a first object of the present invention is to provide a multiplex communication system in

which operational data can be transmitted at different frequencies according to the degree of necessity of transmitting the data to a bus line.

A second object of the present invention is to provide a multiplex communication system in which the transmitting and receiving node devices can be identified without having to append address data to the transmitting message data, and a large amount of data can be transmitted without interfering with each other, thereby avoiding a time lag in the processing of controlling vehicle-loaded equipment or the like.

In order to achieve the above first object, according to a first aspect of the present invention, there is provided a multiplex communication system in which a plurality of items of operational data are transmitted in every transmission cycle, in a time division multiplexing manner, via a bus line from a plurality of control devices to at least one of a plurality of end devices to be controlled, the improvement comprising that the items of operational data are divided into a plurality of degrees according to the necessity of transmission, wherein the operational data falling into the greatest degree of transmission necessity is transmitted once in every transmission cycle, while the operational data falling into the smaller degree of transmission necessity is transmitted once in every few transmission cycles according to the degree of the transmission necessity.

In order to achieve the second object of the present

invention, according to the second aspect of the present invention, there is provided a multiplex communication system in which a plurality of node devices are connected to a bus line so as to cyclically transmit and receive message data with each other and to execute processing of the received data, wherein the improvement comprises that one of the node devices functions as a master node device so as to determine a transmission cycle of the message data from all the node devices and to take the initiative in determining a transmission timing within the transmission cycle at which each of the node devices, including its own device, transmits the message data onto the bus line, the transmission timing being associated with each of the node devices, so that each of the devices sends the message data to be addressed to another device onto the bus line at the transmission timing determined by the master node device.

A time slot provided at the transmission timing associated with each of the node devices may be divided into a plurality of sub-time slots, and the sub-time slots may be arranged to correspond to the individual node devices to receive the message data transmitted from one of the node devices.

According to the foregoing construction of the first aspect of the present invention, a plurality of items of operational data to be transmitted to the bus line from a plurality of control units, respectively, are divided into a plurality of degrees which have been determined according to the transmission necessity (urgency). The operational data

falling into the greatest degree of transmission necessity is positively transmitted once in every transmission cycle. On the other hand, the data falling into the smaller degrees of transmission necessity is transmitted once in every few cycles according to the degree of urgency.

With this arrangement, signals (data) having the greater necessity (urgency) of transmission, such as an air bag signal and door lock/unlock signals that are respectively output from a collision detecting section and a door lock/unlock detecting section among a plurality of vehicle-loaded control units, are positively transmitted once in every cycle. This arrangement inhibits a time lag in transmitting signals having the greater degree of transmission necessity, which further ensures safety for the driver and passengers.

Additionally, signals (data) having the smaller degree of necessity (urgency) of transmission, such as a window opening/closing instruction signal and a remote control mirror driving signal that are respectively output from a window opening/closing section and a mirror actuating section among a plurality of vehicle-loaded control units, are transmitted only once in every few cycles according to the degree of urgency. This arrangement makes it possible to reliably operate each end device to accomplish a required function based on the operational signal (data) without interfering with the transmission timing of signals having the greater degree of urgency.

Further, according to the second aspect of the present

invention, the timing at which each node device transmits message data has been determined. Also, the individual sub-time slots obtained by dividing the time slot that is arranged at the above-described predetermined timing are allocated to the individual node devices to receive the message data. With this arrangement, each node device is able to transmit message data to a desired end device without having to append the sender and receiver information to the transmitting data merely by carrying the data onto the sub-time slot provided for the associated end node device within the time slot allocated to its own device.

Through use of this multiplex communication system, it is thus possible to perform faster transmission of message data without a time loss, which further shortens a transmission cycle of message data from the respective node devices. By the application of this system to vehicle-loaded equipment or the like, it is possible to prevent a time lag in the processing of controlling the equipment.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a circuit diagram illustrating the construction of a multiplex communication system according to a first embodiment of the present invention;

Fig. 2 illustrates the operation of the system shown in Fig. 1 in which data is transmitted via a bus line in a time division multiplexing manner;

Fig. 3 is a block diagram illustrating an example of

the construction of a multiplex communication system according to a second embodiment of the present invention;

Fig. 4 illustrates the construction of message data transmitted to the bus line in the system shown in Fig. 3; and

Fig. 5 is a flow chart illustrating the operation of the second embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A detailed description will now be given of a first embodiment of a multiplex communication system according to the present invention.

Fig. 1 is a circuit diagram illustrating the construction of a first embodiment of a multiplex communication system according to the present invention. More specifically, Fig. 1 illustrates an example of a multiplex communication system loaded in a vehicle. Fig. 2 illustrates one example of the operation of the multiplex communication system shown in Fig. 1 in which operational data is transmitted in a time division multiplexing manner via a bus line.

Referring to Fig. 1, first to eleventh control units 1 to 11 are loaded in the common vehicle, and first to fourth end devices to be controlled 12 to 15 are also loaded in the same vehicle. The first to eleventh control units 1 to 11 respectively include at least operational switches 1s to 11s, and motors 1m to 11m which are interlocked with the

switches 1s to 11s. The first to fourth end devices 12 to 15 respectively include at least motors 12m to 15m. A first changeover switch 16 has a single circuit with a plurality of contacts whose plurality of fixed contacts are respectively connected to the output terminal of the first control unit 1, the output terminal of the second control unit 2, and the respective movable contacts of second and third changeover switches 17 and 18 each having a single circuit with a plurality of contacts. The movable contact of the first changeover switch 16 is connected to a bus line 21. A plurality of fixed contacts of the second changeover switch 17 are respectively connected to the output terminals of the third, fourth and fifth control units 3, 4 and 5. A plurality of fixed contacts of the third changeover switch 18 are respectively connected to the output terminals of the sixth, seventh and eighth control units 6, 7 and 8. A plurality of fixed contacts of a fourth changeover switch 19 are respectively connected to the output terminals of the ninth, tenth and eleventh control units 9, 10 and 11. A fifth changeover switch 20 also has a single circuit with a plurality of contacts whose fixed contacts are respectively connected to the input terminals of the first to fourth end devices 12 to 15. The movable contact of the fifth changeover switch 20 is connected to the bus line 21. An overall control apparatus 22, which is coupled to a storage unit 23, is connected at its output terminal to the first to fifth changeover switches 16 to 20 so that it can exert control over the switching of the contacts of the first to

fifth switches 16 to 20.

The operation of the system of this embodiment constructed as described above will now be explained with reference to Fig. 2.

When the key is inserted to the vehicle, the control apparatus 22 starts the control operation. At the start of the operation, the apparatus 22 reads a program which has been stored in the storage unit 23 and permits a built-in buffer memory, or the like, to store information representing the degrees of necessity of transmitting the respective items of operational data, that is, the degrees of urgency of transmitting the data. The information read by the control apparatus 22 determines the switching states of the contacts of the first to fifth switches 16 to 20 and the timing of switching the contacts of the switches 16 to 20. Subsequently, when a first transmission cycle of a plurality of items of operational data is started, the control apparatus 22 causes the contact of the first switch 16 to be sequentially switched from one end to the other end of the fixed contacts at required switching timings. In synchronization with switching the contacts of the first switch 16, the control apparatus 22 also causes the contacts of the second to fourth changeover switches 17 to 19 to be switched according to the content of the above-described information.

An explanation will now be given with reference to Fig. 2 of one example of the switching operation of the respective contacts of the first to fourth switches 16 to

19. The movable contact of the first switch 16 is initially switched and connected to a first fixed contact 16_1 for a given period t so that operational data 1d can be transmitted to the bus line 21 from the first control unit 1. Then, the movable contact of the first switch 16 is switched and connected to the second fixed contact 16_2 for a given period t so that operational data 2d can be transmitted to the bus line 21 from the second control unit 2.

Thereafter, the movable contact of the first switch 16 is switched and connected to the third fixed contact 16_3 for a given period 2t, which is twice as long as the above-described period t. This is because of the following reason. During the switching and connecting operation of the movable contact of the first switch 16 to the fixed contact 16_3, the movable contact of the second switch 17 is sequentially switched and connected to the first and second fixed contacts 17_1 and 17_2, each for the given period t. Simultaneously with this switching and connecting operation, two items of operational data 3d and 4d are sequentially transmitted to the bus line 21 from the third and fourth control units 3 and 4, respectively.

Then, the movable contact of the first switch 16 is switched and connected to the fourth fixed contact 16_4, during which time the movable contact of the third switch 18 is sequentially switched and connected to the first and second fixed contacts 18_1 and 18_2, each for the given period

t, in a manner similar to the connection of the movable contact of the first switch 16 to the third fixed contact 16_3. Because of this switching and connecting operation, two items of operational data 6d and 7d are sequentially transmitted to the bus line 21 from the control units 6 and 7, respectively. Finally, the movable contact of the first switch 16 is changed and connected to the fifth fixed contact 16_5, during which time the movable contact of the fourth switch 19 is sequentially changed and connected to the first and second fixed contacts 19_1 and 19_2, each for a given period t. Because of this switching and connecting operation, two items of operational data 9d and 10d are transmitted to the bus line 21 from the control units 9 and 10, respectively.

As a consequence of these switching and connecting operations, the operational data 1d to 4d, 6d and 7d, and 9d and 10d are transmitted in the time division multiplexing manner to the bus line 21 from the first to the fourth, the sixth and seventh, and the ninth and tenth control units, respectively (the combination of these items of operational data shall be referred to as a first combination of operational data).

In this first transmission cycle, if the operation switches 1s to 4s, 6s and 7s, and 9s and 10s of the first to the fourth, the sixth and the seventh, and the ninth and the tenth control units 1 to 4, 6 and 7, and 9 and 10, respectively, are not actuated at all in the transmission

timings allocated to the above-described control units, the respective items of operational data 1d to 4d, 6d and 7d, and 9d and 10d transmitted from the control units indicate zero, i.e., the data items do not contain any information. On the other hand, if any of the switches 1s to 4s, 6s and 7s, and 9s and 10s is actuated, the operational data among the data items of 1d to 4d, 6d and 7d, and 9d and 10d transmitted from the associated control unit(s) whose switch(es) are actuated indicates that the data item contains information.

Upon completion of the first transmission cycle, after a lapse of a given transmission interval, a subsequent (second) transmission cycle is started to once again transmit a plurality of items of operational data in a time division multiplexing manner. In the second transmission cycle, the respective items of operational data 1d and 2d are positively transmitted to the bus line 21 from the first and second control units 1 and 2, respectively, by the switching and connecting operation of the contacts of the first to fourth switches 16 to 19 under the control of the control apparatus 22. In contrast, the items of operational data 3d, 4d, 6d, 7d, 9d and 10d from the third, fourth, sixth, seventh, ninth and tenth control units, 3, 4, 6, 7, 9 and 10, respectively, are not transmitted. Instead, the items of operational data 5d, 8d and 11d from the fifth, eighth and eleventh control units 5, 8 and 11, respectively, which have not been transmitted during the first transmission cycle, are transmitted to the bus line 21. As

a consequence, during the second transmission cycle, the items of operational data 1d, 2d, 5d, 8d and 11d are transmitted to the bus line 21 from the first, second, fifth, eighth and eleventh control units 1, 2, 5, 8 and 11, respectively, in a time division multiplexing manner (the combination of these items of operational data shall be referred to as a second combination of operational data).

Upon completion of the second transmission cycle, after a lapse of a given transmission interval, a third transmission cycle is initiated. In the third transmission cycle, the first combination of operational data obtained during the first transmission cycle is once again transmitted in a time division multiplexing manner. In a subsequent fourth transmission cycle, the second combination of operational data obtained during the second transmission cycle is once again transmitted in a time division multiplexing manner. The same applies to after the fourth transmission cycle. Every time an updated transmission cycle is started after a lapse of a given transmission interval, the first and second combinations of operational data are alternately transmitted to the bus line 21 in a time division multiplexing manner.

Every time a transmission cycle is started, the control apparatus 22 causes the movable contact of the fifth switch 20 to be switched in a required order. Due to this switching operation, every time operational data is transmitted to the bus line 21, an associated end device to receive the transmitted data is selected by switching the

movable contact of the fifth switch 20. For example, if the operational data 1d is addressed to the first end device 12, and the operational data 2d is addressed to the second end device 13, the movable contact of the fifth switch 20 should be switched to the first fixed contact 20_1 connected to the end device 12 and to the second fixed contact 20_2 connected to the second end device 13 in accordance with the transmission timing of the data 1d and 2d to the bus line 21. The same applies to the other items of operational data. Namely, in accordance with the transmission timing of the data to the bus line 21, the movable contact of the fifth switch 20 should be changed so that an associated end device(s) to receive the transmitted data can be selected. The motor provided with the associated end device then suitably acts upon the content of the data so that a required operation can be performed in the end device supplied with the transmitted data.

In this embodiment, the operational data having a greater degree of urgency corresponds to air bag signals that are output from a collision detecting section, door lock/unlock signals that are output from a door lock/unlock detecting section, and so on. On the other hand, the data having a smaller degree of urgency corresponds to window opening/closing instruction signals that are output from a window opening/closing section, remote control mirror driving signals that are output from a mirror actuating section, and so on.

In this embodiment, each of the movable contacts of the second to fourth switches 17 to 19 is sequentially switched and connected to the associated two fixed contacts while the first switch 16 is switched and connected to each of the third to fifth fixed contacts 16_3 to 16_5. However, each of the movable contacts of the second to fourth switches 17 to 19 may be switched and connected to only one of the fixed contacts while the first switch 16 is switched and connected to each of the third to fifth fixed contacts 16_3 to 16_5. Alternatively, each of the movable contacts of these switches may be switched and connected to three fixed contacts or more.

Further, this embodiment has been explained in which the two items of operational data 1d and 2d are positively transmitted from the first and second control units 1 and 2, respectively, in every transmission cycle, while the operational data items 3d, 4d, 6d, 7d, 9d and 10d from the control units 3, 4, 6, 7, 9 and 10, respectively, and the data items 5d, 8d and 11d from the control units 5, 8 and 11, respectively, are alternately transmitted in every other cycle. However, this arrangement is not essential. That is, the data that is positively transmitted in every transmission cycle is not restricted to 1d and 2d, and instead, the data from the other control units may be selected as long as it is required to be transmitted very urgently. Also, the number of items of data to be transmitted is not limited to two, and instead, three or

more items of data may be selected.

Moreover, in the above-described embodiment, the respective items of operational data 1d to 11d are divided into two degrees depending on the transmitting urgency, i.e., one degree formed of the data items 1d and 2d that are positively transmitted once in every transmission cycle, and the other degree formed of the other data items 3d to 11d that are alternately transmitted in every other cycle. However, the degrees of necessity (urgency) of transmitting the data are not limited to two, but may be three or more as required. A plurality of degrees of transmitting urgency may be accomplished by the following modification. A plurality of changeover switches each having a single circuit with a plurality of contacts are used and suitably switched to a plurality of control units. At the same time, the switching periods of the change-over switches, each having a single circuit with a plurality of contacts, are selected by the control apparatus 22. With this modification, the following three types of operational data can be generated: the data transmitted in every transmission cycle; the data transmitted in every other cycle; and the data transmitted in every two or three cycles.

As will be clearly understood from the foregoing description, the first embodiment offers the following advantages.

A plurality of items of operational data 1d to 11d transmitted to the bus line 21 from a plurality of control units 1 to 11, respectively, are divided into a plurality of

degrees which have been determined according to the necessity of transmission. The operational data falling into the greater degree of transmission necessity is positively transmitted once in every transmission cycle. On the other hand, the data falling into the smaller degree of transmission necessity is transmitted once in every few cycles according to the degree of necessity. As described above, signals having the greater necessity (urgency) of transmission, such as air bag signals and door lock/unlock signals that are respectively output from the collision detecting section and the door lock/unlock detecting section among the vehicle-loaded control units 1 to 11, are positively transmitted once in every cycle. This arrangement inhibits a time lag in transmitting signals having the greater degree of necessity (urgency), which further ensures safety for the driver and passengers.

Additionally, as described above, signals (data) having the smaller degree of transmitting necessity (urgency), such as window opening/closing instruction signals and remote control mirror driving signals that are respectively output from the window opening/closing section and the mirror actuating section among the control units 1 to 11, are transmitted only once in every few cycles according to the degree of urgency. This arrangement makes it possible to reliably operate a desired end device to accomplish a required function based on the operational signal (data) without interfering with the transmission timing of signals having the greater degree of urgency.

The multiplex communication system loaded in a vehicle has been discussed in this embodiment by way of example. However, this system is not only applicable to a vehicle, but also to other uses as long as the system is adequate to generate a plurality of items of data that can be distinctly differentiated into the degrees of transmission urgency and also to transmit them in a time division multiplexing manner.

A second embodiment of a multiplex communication system according to the present invention will now be explained in detail with reference to Figs. 3 to 5.

Fig. 3 is a block diagram illustrating the construction of a multiplex communication system according to the second embodiment. Fig. 4 illustrates the construction of message data transmitted to a bus line. Fig. 5 is a flow chart illustrating the operation of this embodiment. Fig. 3 shows a bus line 21, a master node device M, slave node devices A and B, actuators Da to De, and switches Sa to Sh.

More specifically, the multiplex communication system of the second embodiment comprises the single common bus line 21, the master node device M connected to the bus line 21 so as to determine the transmission timings of all the items of message data in the communication system, and a plurality of slave node devices A and B connected to the bus line 21. It will now be assumed that this system is installed in a vehicle for controlling vehicle-loaded equipment and for other reasons. The master node device M is connected to peripheral equipment, for example, mounted

on the driver's seat, such as switches Sa and Sb indicating the states of the door and the window and the state of the window opening/closing switch, etc., and actuators Da and Db, such as a door lock motor, a power window motor, etc. With this construction, the master node device M collects data indicating the state of the switches Sa and Sb and transmits it to the bus line 21 as required so as to exert control over the actuators Da and Db. On the other hand, the slave node devices A and B are connected to peripheral equipment, for example, mounted on the passenger's front seat and on the rear seats so that they can collect and transmit data so as to exert control over the respective actuators, in a manner similar to the master node device M.

Each of the master node device M and the slave node devices A and B is provided with a CPU. The master node device M takes the initiative in determining the transmission timing and cycle of the message data onto the bus line 21. More specifically, the node device M exerts control over the transmission timing and cycle by use of a clock timer of the CPU contained in its own device so that the message data can be transmitted to the bus line 21 from each of the master node device M and the slave node devices A and B at a predetermined timing and cycle. The master node device M transmits and receives message data with the salve node devices A and B in accordance with the above-described predetermined timing and cycle so that it can exert control over required actuators.

The transmission timing and cycle of the message data

transmitted to the bus line 21 are determined as indicated in Fig. 4. This will be explained in greater detail below.

As shown in Fig. 4, the transmission cycle of the message data has been set as a start pulse transmitted to the bus line 21 from the master node device M. This cycle has been set so as not to cause a time lag in the data processing executed in the respective node devices. Each of the time intervals between start pulses is divided into a plurality of time slots which have been allocated to the individual node devices, during which slot the node devices transmit and receive message data with each other.

In the example shown in Fig. 4, in a first time slot subsequent to the start pulse, the master node device M transmits message data to the other node devices. In a second time slot, the slave node device A transmits message data to the other node devices. In a third time slot, the slave node device B transmits message data to the other node devices. Similarly, subsequent time slots are arranged for executing data transmission among different node devices. For identifying the respective time slots, time intervals, which are different from the pulse length of the start pulse, each intervene between the time slots.

Each time slot used for transmitting message data from each node device to the other node devices is divided into a plurality of sub-time slots which can carry data formed of one bit or a plurality of bits. Each time slot has been allotted to a predetermined node device for transmitting message data, as described above, and the sub-time slots

have also been allocated to the end node devices to receive such data. For example, the leading sub-time slot within the time slot allocated to the data transmission of the slave node device A is used to transmit message data from the slave node device A to the master node device M. A subsequent sub-time slot is used to transmit message data from the slave node device A to the slave node device B.

As has been discussed above, in the second embodiment the timing and cycle for transmitting message data to the bus line 21 have been determined. Additionally, during the individual sub-time slots within each time slot that can carry message data, it has been determined which node device can transmit data to which end device. With this arrangement, each node device connected to the bus line 21 can be notified which message data is to be addressed to its own device merely by monitoring the time slots on the bus line 21 after acknowledging the receipt of a start pulse from the master node device M. Each node device can also be notified which time slot can be used to transmit message data from its own device.

This arrangement enables each of the node devices, including the master node device M, to receive message data from the other node devices as required, and to control the actuator, etc. connected to its own device. Each node device is also able to transmit to a desired node device the state of switches indicating the status of the various types of equipment connected to its own device.

The operation of the second embodiment of the present

invention will now be described with reference to the flow chart of Fig. 5. In this embodiment, the multiplex communication system constructed of the master node device M and the slave node devices A and B, all of which are connected to the bus line 21, will be taken as an example.

(1) The master node device M first transmits a start pulse to the bus line 21 (step 301).

(2) Subsequent to the transmission of the start pulse, the time slot allocated to the data transmission of the master node device M is started. The node device M thus transmits message data that is addressed to a desired slave node device by use of the associated sub-time slot (step 302).

(3) Upon completion of the transmission by use of the time slot allocated to the master node device M, a subsequent time slot allocated to the data transmission of the slave node device A is initiated. The master node device M thus monitors the start of transmitting message data from the slave node device A (step 303), and also monitors a lapse of a predetermined time provided for transmission from the node device A (step 305).

(4) If there is any message data addressed to the master node device M from the slave node device A, the node device M receives it by use of the sub-time slot allocated to its own device (step 304).

(5) If the transmission of the message data from the slave node device A is not started after a lapse of the above-described transmission predetermined time (step 305),

the master node device M executes transmission error handling in respect of the slave node device A (step 306).

(6) Upon completion of data transmission by use of the previous time slot, a subsequent time slot allocated to data transmission of the slave node device B is started. The master node device M monitors the start of the transmission of message data from the slave node device B (step 307), and also monitors a lapse of a predetermined transmission time provided for the node device B (step 309).

(7) If there is any message data addressed to the master node device M from the slave node device B, the node device M receives the data by use of the sub-time slot allotted to its own device (step 308).

(8) If the transmission of the message data from the slave node device B is not started after a lapse of the above-described predetermined time, the master node device M executes transmission error handling in respect of the slave node device B (step 310).

(9) The master node device M goes into a standby position until the transmission time of a subsequent start pulse is reached (step 311), and returns to step 301 to transmit the subsequent start pulse (step 311).

The operation of the system has been discussed in terms of the sequence of the master node device M. An explanation will now be given of the operation of the slave node device A in relation to the master node device M.

(10) The slave node device A monitors the bus line 21 in the standby position until a start pulse is transmitted

from the master node device M (step 321).

(11) Upon acknowledgement of the receipt of the start pulse, the time slot allocated to the data transmission of the master node M is started. The slave node device A thus receives the message data from the master node device M in the sub-time slot allocated to its own device (step 322).

(12) Upon completion of the previous slot, a subsequent time slot allocated to the data transmission of the slave node device A is initiated. The node device A thus transmits message data that is to be addressed to the master node device M and the other slave node device by use of the respective associated sub-time slots (step 323).

(13) A subsequent time slot allocated to the data transmission of the slave node device B is started. The node device A thus monitors the start of transmitting message data from the node device B (step 324), and also monitors a lapse of a predetermined transmission time provided for the node device B (step 326).

(14) If there is any message data addressed to the slave node device A from the node device B, the node device A receives the data in the sub-time slot allotted to its own device (step 325).

(15) If the transmission of the message data from the slave node device B is not started after a lapse of the above-described predetermined transmission time, the node device A executes transmission error handling in respect of the node device B (step 327).

(16) Upon completion of the processing of either of

steps 325 or 327, the slave node device A returns to step 321 to continue to receive data in a subsequent cycle.

The slave node device B is operated in a manner similar to the node device A. An explanation will thus be given only of the operation in which the node device B ignores the message data transmitted from the node device A.

(17) The slave node device B monitors the bus line 21 and is stationed at the standby position until it receives a start pulse from the master node device M (step 331).

(18) Upon acknowledgement of the receipt of the start pulse, the time slot allocated to the data transmission of the master node device M is started. The slave node device B thus receives the message data contained in the sub-time slot allotted to its own device (step 332).

(19) Upon completion of the previous slot, a subsequent time slot allocated to the data transmission of the slave node device A is started. During this time slot, the node device B can ignore the unnecessary data from the node device A (step 333), and can be stationed in the standby position until the transmission of the message data from the slave node device A is completed (step 334).

(20) Upon completion of the previous time slot, the time slot allocated to the data transmission of the slave node device B is started. The node device B thus transmits message data that is to be addressed to the master node device M and the other slave node device by use of the respective associated sub-time slots (step 335), and returns to step 331 to continue to receive subsequent data.

This embodiment has been explained in which the multiplex communication system is constructed of the master node device M and the slave node devices A and B, all of which are connected to the common bus line 21. However, this construction is not exclusive. The present invention is also operable when the slave node devices are connected to a plurality of bus lines.

Also, in this embodiment, the master node device M takes the initiative in determining the transmission timing of message data from each of the node devices onto the bus line. However, the master node device M may be constructed as desired. Also, if the master node device M becomes at fault during operation, a desired slave node device may be constructed to act as the master node device. This modification can be achieved by programming into each node device, conditions, such as the states of the other node devices required when its own device functions as the master node device.

As will be clearly understood from the foregoing description, the present invention offers the following advantages.

A plurality of items of operational data to be transmitted to the bus line from a plurality of control units, respectively, are divided into a plurality of degrees which have been determined according to the transmission necessity. The operational data falling into the greatest degree of transmission necessity is positively transmitted once in every transmission cycle. On the other hand, the

data falling into the smaller degree of transmission necessity is transmitted once in every few cycles according to the degree of urgency. By the application of this system to a vehicle by way of example, signals having the greater necessity (urgency) of transmission, such as air bag signals and door lock/unlock signals that are respectively output from the collision detecting section and the door lock/unlock detecting section among a plurality of vehicle-loaded control units, are positively transmitted once in every cycle. This arrangement inhibits a time lag in transmitting signals having the greater degree of transmission urgency, which further ensures safety for the driver and passengers.

Additionally, by the application of the multiplex communication system to a vehicle by way of example, signals (data) having the smaller degree of transmitting necessity (urgency), such as window opening/closing instruction signals and remote control mirror driving signals that are respectively output from the window opening/closing section and the mirror actuating section among a plurality of vehicle-loaded control units, are transmitted only once in every few cycles according to the degree of urgency. This arrangement makes it possible to reliably operate each end device to accomplish a required function based on the operational signal (data) without interfering with the transmission timing of signals having the greater degree of urgency.

Further, each node device is able to transmit message

data to a desired end device without appending the sender and receiver information to the data merely by carrying the data onto the sub-time slot corresponding to the end node device within the time slot allocated to its own device. This makes it possible to perform faster transmission of message data without a time loss, which further shortens a transmission cycle of message data from the respective node devices, thereby preventing a time lag in the control processing of vehicle-loaded equipment.

CLAIMS

1. A multiplex communication system in which a plurality of items of operational data are transmitted in every transmission cycle, in a time division multiplexing manner, via a bus line from a plurality of control devices to at least one of a plurality of end devices to be controlled, wherein said items of operational data are divided into a plurality of degrees according to the necessity of transmission, wherein the operational data falling into the greatest degree of transmission necessity is transmitted once in every transmission cycle, while the operational data falling into the smaller degrees of transmission necessity is transmitted once in every few transmission cycles according to the degree of the transmission necessity.

2. A multiplex communication system according to Claim 1, wherein said items of operational data are divided according to a program which has been stored in a storage unit, under the control of a control apparatus.

3. A multiplex communication system according to Claim 1 or Claim 2, wherein said control units and said bus line, and said end devices and said bus line are selectively switched and connected by a plurality of change-over switches which are changed under the control of said control apparatus.

4. A multiplex communication system according to any one of Claims 1 to 3, wherein said control units are control unit equipment loaded in a common vehicle, and said end devices are equipment to be controlled which is loaded in the same vehicle and controlled by the operation of said control unit equipment.

5. A multiplex communication system according to any one of Claims 1 to 4, wherein said items of operational data are divided into the degrees of transmission necessity based on the urgency of

transmitting said data.

6. A multiplex communication system in which a plurality of node devices are connected to a bus line so as to cyclically transmit and receive message data with each other and to execute processing of the received data, wherein one of said node devices functions as a master node device so as to determined a transmission cycle of the message data from all the node devices and to take the initiative in determining a transmission timing within said transmission cycle at which each of said node devices, including its own device, transmits the message data onto said bus line, said transmission timing being associated with each of said node devices, so that each of said devices sends the message data to be addressed to another device onto said bus line at said transmission timing determined by said master node device.

7. A multiplex communication system according to Claim 6, wherein a time slot provided at said transmission timing associated with each of said node devices is divided into a plurality of sub-time slots, and said sub-time slots are arranged to correspond to the individual node devices to receive the message data transmitted from one of said node devices.

8. A multiplex communication system according to Claim 6 or Claim 7, wherein one of said node devices acts as said master node device if a failure occurs to said master node device.

9. A multiplex communication system according to any one of Claims 6 to 8, wherein each of said node devices, including said master node device, has a CPU, wherein the CPU of said master node device determines said transmission cycle and said transmission timing associated with each of said node devices arranged within said cycle, while the CPUs of said node devices, including said master node device, controls the transmission timings so that the

message data is transmitted from said devices at the timings determined by the CPU of said master node device.

10. A multiplex communication system substantially as hereinbefore described with reference to, and as illustrated by, the accompanying drawings.

The Patent Office

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Application No:	GB 9521853.3	**Examiner:**	Simon Rees
Claims searched:	1-5 and 10	**Date of search:**	18 January 1996

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): H4M (MN, MTX1), H4P (PPK, PPNB), G4H (W, NEC, NEE, NF)

Int Cl (Ed.6): H04J (3/16), H04L (12/40, 12/42), B60R (16/02)

Other: ONLINE: WPI, INSPEC

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A,E	GB2290682A	(NIPPONDENSO) Whole document.	1
A	EP0192819A2	(HITACHI) Whole document, especially lines 3-10 on page 4, lines 6-10 of page 6 and lines 6-21 of page 21.	1-5
X	WO89/02141A1	(ERICSSON) Whole document, especially from line 29 of page 2 to line 4 of page 3, and from line 16 of page 4 to line 4 of page 5 .	1-5
X	US5343472A	(MICHIHIRA) Whole document, especially lines 5-67 of column 2 and lines 24-37 of column 3.	1-5

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